QUALITY OF CARCASS AND MEAT IN BULLOCK OF DIFFERENT GENOTYPES RAISED UNDER ORGANIC SYSTEM

QUALITA' DELLA CARCASSA E DELLA CARNE DI VITELLONI DI DIVERSO GENOTIPO ALLEVATI CON SISTEMA BIOLOGICO

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SUMMARY

Carcass and meat quality of three muscles from 17 Limousine and 17 Limousine x Red Pied organically-raised beef cattle were studied. The carcasses were classified according to the European (S)EUROP classification scale and some linear measurements were taken. After an 8-day ageing period, *longissimus thoracis*, *triceps brachii* and *semitendinosus* muscles were excised from all carcasses and subjected to the following analyses: pH, meat colour, water holding capacity, tenderness, chemical composition and fatty acid profile. The carcasses deriving from the two genetic types were of medium conformation and had a slight fattening degree; the Limousine bullocks produced meat which was lighter and paler in colour, more tender and with a lower percentage of intramuscular fat. Comparison between muscles showed that the *semitendinosus* had higher values of Lightness (L*) and Hue (H*), thus giving lighter and paler meat, but it was less tender and had a higher cooking loss. Meat quality characteristics of *triceps brachii* and *longissimus thoracis* muscles were similar; the meat analysed had a very low content of intramuscular fat, expressed as ether extract. Only slight differences between muscles were found in the fatty-acid profile.

Key words: organic-system, carcass, beef, quality.

RIASSUNTO

Nel presente lavoro sono riportati i risultati di una prova tesa a valutare la qualità delle carcasse e delle carni derivate da 17 vitelloni Limousine e da 17 vitelloni Limousine x Pezzata Rossa allevati con sistema biologico. Le carcasse sono state classificate in base alle norme Comunitarie (S)EUROP e, su di esse, sono state rilevate alcune misure lineari. Dopo 8 giorni di frollatura i muscoli *longissimus thoracis, triceps brachii* e *semitendinosus* sono stati prelevati da ogni carcassa e sottoposti alle seguenti analisi: pH, colore, potere di ritenzione idrica tenerezza, composizione chimica centesimale e composizione acidica. Le carcasse derivate dai

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due tipi genetici esaminati hanno mostrato una conformazione media (R) ed un ridotto stato di ingrassamento (2). I vitelloni Limousine hanno fornito carne più luminosa e chiara, più tenera e con un minore contenuto in grasso intramuscolare. Il confronto fra muscoli ha mostrato che la carne derivata dal muscolo *semitendinosus* risulta più luminosa e chiara, come si evince dai più alti valori di Luminosità (L*) e di Tinta (H*), ma mostra più elevati valori di sforzo di taglio e maggiori perdite di cottura. La qualità della carne derivata dai muscoli *triceps brachii* e *longissimus thoracis* è risultata simile. In generale, la carne analizzata ha mostrato un ridotto contenuto in grasso intramuscolare, espresso come estratto etereo e solo lievi differenze fra i muscoli sono state evidenziate per quanto riguarda il profilo acidico.

Parole chiave: allevamento biologico, bovino, carcassa, carne, qualità.

INTRODUCTION

Organic beef production mainly provides to raise the animals with non-intensive methods and to use feed derived from organic cultivation. The breed choice, breeding program and feeding plan must contribute to avoid pathological conditions, since conventional pharmaceuticals are forbidden. Use of alternative medicine is a priority; furthermore, the regulations concerning organic beef production do not allow the use of substances stimulating the growth of the animals (Council Regulation EC No 1804/99). In general, the regulations tend to promote the quality of the production, although this sometimes occurs at the expense of quantity. Today's consumers are especially involved and interested in nutritional quality, and are increasingly wary about meat, after being profoundly disillusioned and alarmed by recent news reports. For this reason they are turning to organic products with great interest, and seek certifiably wholesome quality, although they are unwilling to forego the organoleptic, dietetic and technological qualities of the meat (Fernàndez & Woodward, 1999; Hermansen, 2003; Kouba, 2003). Regarding beef production, studies have not yet provided us with complete information concerning the effects of the organic livestock production system on the productive performance of beef cattle (Younie et al., 1990; Younie, 1992; Woodward & Fernàndez, 1999; Hansson et al., 2000; Sundrum, 2001). As a contribution to this interesting subject, a study to evaluating the production of beef from Limousine and Limousine x Red Pied cattle raised according to the organic system was carried out.

MATERIALS AND METHODS

34 bullocks of two genotypes (17 Limousine and 17 crossbred Limousine x Red Pied) were reared in the same farm according to the organic system. They were dam-reared to the age of weaning (7 months of age) on natural pasture of S. Rossore Park in Tuscany (Italy) and then they remained on the same pasture where no feeding supplementation was offered. Animals were slaughtered at 23 months of age in a commercial EU licensed abattoir; carcasses were refrigerated for 24h at 4°C

and classified according to the European (S)EUROP classification scale (Council Regulation EEC No 1208/81; No 1026/1991): carcass conformation and fatness score were estimated by an experienced evaluator. Some linear measurements were taken on all carcasses: carcass length (from the anterior edge of symphysis pubis to the middle of the anterior edge of the visible part of the first rib), chest depth (at the level of the 5th rib from the dorsal edge of the spinal canal to the ventral aspect of the middle of the body of the 5th sternebra), leg length (from the medial malleolus of the tibia in a straight line to the anterior edge of the symphysis pubis) and maximum width of leg (the horizontal distance between the outmost points on the medial and the lateral surface of the leg) (De Boer et al., 1974); carcass evaluation was supplemented by calculation of carcass compactness index (carcass weight/carcass length). Carcasses were aged for 8 days at 4°C in the same refrigerating room; after ageing, *triceps brachii* muscles were removed from the right forequarters, and *longissimus thoracis* and *semitendinosus* muscles were excised from the right hindquarters. To evaluate some meat quality characteristics, 10-cm-thick slices of *longissimus thoracis* (7th-8th thoracic vertebrae), *semitendinosus* and *triceps brachii* (from the central part of the muscles) were removed and underwent analysis.

pH and meat colour

The pH of all muscles was determined using a Hanna pH211 pH-meter provided with a Hanna FC 200B electrode and an automatic temperature compensator (Hanna Instruments, Padova, Italy).

Meat colour was evaluated on a 2.5-cm-thick slice of meat, using a Minolta CR300 colorimeter (Illuminant D 65) (Minolta Camera Co. Ltd, Osaka, Japan), calibrated against a standard white tile in the CIEL*a*b* system, which measures the values of Lightness (L*), redness (a*), yellowness (b*), then calculates Chroma (C*) and Hue (H*) (Renerre, 1982). Prior to colour evaluation, each sample was allowed to oxygenate at 4°C for 1 h.

Water holding capacity

The meat's water holding capacity was determined by two different methods:

- Drip loss: the percentage of weight loss of a 2.5-cm-thick slice of meat kept at 4°C for 48 h in a plastic container with a double bottom (Lundström & Malmfors, 1985).

- Cooking loss: the percentage of weight loss of a 2.5-cm-thick slice of meat during cooking in a ventilated oven at 180°C to an internal temperature of 75°; sample temperature was detected using a thermocouple thermometer Hanna HI92704C (Hanna Instruments, Padova, Italy).

Tenderness

Tenderness was measured as shear force (kg) using Warner-Bratzler Shears applied to an Instron 1011 (Instron Ltd, High Wycombe, UK), on 1 -inch-diameter cylinders of raw and cooked meat, following a modified Joseph method (1979). For each muscle a minimum of four cylinders about 2.5 cm long were taken in parallel to

muscular fibers and placed inside the Warner-Bratzler, to be sheared perpendicularly to the long axis of the muscle fibers.

Chemical analysis

Dry matter, ether extract, crude protein and ash of each sample were determined according to AOAC methods (1990).

Fatty acid composition of the intramuscular fat was determined using the method of Folch et al. (1957); the extracts were methylated and subjected to gas-chromatographic analysis on a ω-wax 0.32-mm capillary column. The schedule used for the analysis was as follows: 160°C for the first 7 min, increased by 3°C every minute until a temperature of 200°C was reached, where it remained for 30 min; the detector and injector temperatures were held at 200°C.

Statistical analysis

Data were studied with a two-criteria variance analysis (SAS, 1995), taking into account the genotype and the muscle examined; the interaction genotype x muscle was never significant, and was therefore not reported in the tables.

RESULTS

Carcass quality

Carcass evaluation, according to the EU classification system, showed an ordinary conformation (score: R) and a slight fat cover (score: 2) in both the Limousine bullocks and Limousine x Red Pied crosses.

Carcass characteristics are reported in Tab. I. The subjects studied in this trial

Tab. I. Carcass characteristics of Limousine (L) and Limousine x Red Pied (L x RP).

	Genotype (G)		
	L	L x RP	S.E.
n	17	17	
Carcass weight (kg)	337.34	343.59	10.37
Carcass length (cm)	130.32	132.59	1.39
Chest depth (cm)	43.71	45.32	0.67
Leg length (cm)	73.77	74.44	0.88
Max width of leg (cm)	32.41a	28.31b	1.01
Carcass compactness	2.59	2.58	0.07

a, b: $P \leq 0.05$

produced carcasses with an average weight of 340 kg, and for this parameter there was no statistical difference between Limousine and Limousine x Red Pied carcasses.

Maximum leg width was significantly higher in the Limousine bullocks, while the other linear measurements were similar in the two genetic types. Carcass compactness was generally somewhat lower, compared to that observed by Giorgetti et al. (1991) in purebred Limousine bullocks raised with traditional methods. These results may indicate that in spite of the animals' old age at slaughter, subjects had not reached complete commercial maturity, as shown by Sundrum (2001) and by Hansson et al. (2000) in trial on cattle raised according to the organic system.

Meat quality

The qualitative characteristics of the meat are reported in Tab. II. The pH was similar in the two breeds and in the three muscles considered.

Regarding colorimetric characteristics, on the whole, the meat analysed was darker in colour and slightly less light than that of traditionally-raised Limousine cattle (Andrighetto et al., 1994). This was probably due to the fact that meat from the animals raised on pasture is generally darker than that of animals finished on concentrate (Priolo et al., 2001).

When the breeds were compared, it was observed that the purebred Limousines produced meat that was paler and lighter than that of the crosses, as seen in the higher values of Lightness (L*) and Hue (H*).

Meat from *semitendinosus* muscle appeared to be significantly lighter (L*) and paler (H*) than that from the *triceps brachii* and *longissimus thoracis*. Similar results, found by Acciaioli et al. (1995) and by Preziuso & Russo (2004) in Chianina beef, showed that meat derived from the *semitendinosus* muscle always appears to have the colour characteristics which are more desirable for Italian consumers.

These results were also confirmed by Torrescano et al. (2003), who evaluated various quality traits of 14 Swiss Brown beef muscles, and found that *semitendinosus* was significantly lighter than *longissimus lumborum* and *triceps brachii*.

Regarding water-holding capacity, determined either by drip or cooking losses, no statistical differences were noted between Limousine and Limousine x Red Pied beef.

Consistent with Monin & Ouali (1991), there were significant differences between the muscles for cooking loss: the highest losses were observed for the *semitendinosus* muscle, while *longissimus thoracis* and *triceps brachii* showed the lowest values, indicating better water-holding capacity. Similar differences were also found by Acciaioli et al. (1995) and by Preziuso & Russo (2004) on the same muscles from Chianina cattle.

Regarding tenderness, the values for shear force were higher to those found on the meat from Limousine bullocks raised with the traditional system (Andrighetto et al., 1994), probably due to the older age at slaughter, as previously stated.

From the comparison of genetic types, shear force on the raw meat was significantly lower in the Limousine beef, while no differences were revealed for shear force on cooked meat.

Tab. II. Meat quality traits of triceps brachii (Tb), longissimus thoracis (Lt) and semitendinosus (St) muscles of Limousine (L) and Limousine x Red Pied (L x RP) beef.

	Genotype (G)			Muscle (M)			
	L	L x RP	S.E.	Tb	Lt	St	S.E.
n	51	51		34	34	34	
pH	5.41	5.43	0.01	5.42	5.41	5.43	0.01
Meat colour							
L*	44.81a	42.03b	0.43	42.43 b	41.44 b	46.39 a	0.52
a*	24.21	24.49	0.43	24.23	24.20	24.61	0.53
b*	12.34	11.64	0.29	11.33 b	11.42 b	13.22 a	0.36
C*	27.07	27.05	0.49	26.72	26.59	27.86	0.59
H*	26.94a	25.16b	0.34	24.90 b	25.14 b	28.11 a	0.42
Water-holding capacity							
Drip loss (%)	2.07	1.91	0.11	1.83	2.18	1.95	0.14
Cooking loss (%)	32.16	33.05	0.72	31.66 b	30.27 b	35.88 a	0.88
Shear Force							
on raw meat (kg)	12.35b	13.95a	0.41	12.41 b	9.62 c	17.43 a	0.50
on cooked meat (kg)	9.95	9.97	0.23	9.20 b	9.36 b	11.33 a	0.28
Chemical composition							
Dry matter (%)	23.48	23.70	0.16	23.38	23.92	23.48	0.19
Ether extract (%)	0.45b	0.56a	0.04	0.44 b	0.67 a	0.41 b	0.05
Crude protein (%)	21.94	22.10	0.15	21.87	22.19	21.99	0.18
Ash (%)	1.09a	1.05b	0.01	1.07	1.06	1.09	0.01

a, b, c: $P \leq 0.05$

Longissimus thoracis gave more tender meat, as shown by the lowest shear force value; it is possible to note an increasing trend in shear force on raw meat, with statistical differences between *longissimus thoracis*, *triceps brachii* and *semitendinosus*. Cooking process induced notable tenderising of the meat from the *triceps brachii* and *semitendinosus*, but nevertheless for *semitendinosus* higher values of shear force were shown, confirming the greater toughness of the meat derived from this muscle.

The higher tenderness of *longissimus* meat observed in this study is consistent with results reported by Dransfield & Jones (1981), Acciaioli et al. (1995), Torrescano et al. (2003) and Preziuso & Russo (2004) in previous studies comparing different muscles from beef cattle.

Observing the results concerning chemical analysis, it is interesting to note that the percentage of intramuscular fat, expressed as ether extract, is particularly low, also if compared with the results of Poli et al. (1994). This may represent an important dietetic value of this kind of meat for health reasons (Ulbricht & Southgate, 1991), but may negatively influence some sensory properties of meat such as juiciness, flavour, etc. (Seideman et al., 1987; Fiems et al., 2000; Renand et al., 2001).

Even if the meat analysed was very lean, it is possible to note that the bullocks deriving from the Limousine x Red Pied cross provided meat with a significantly higher intramuscular fat content; compared to other muscles, *longissimus thoracis* has a significantly higher percentage of ether extract.

Tab. III reports the fatty acid composition of the meat. The oleic (C18:1), palmitic (C16:0) and stearic (C18:0) fatty acids were the most abundant fatty acids in the intramuscular fat, consistent with data previously reported in the literature (Enser et al., 1998; De Smet et al., 2000; Cifuni et al., 2003).

From comparison with the results obtained by Poli et al. (1994) on traditionally-raised Limousine cattle, in this trial a decreased percentage of linoleic acid (C18:2) is shown as well as a higher content of oleic acid (C18:1) and linolenic acid (C18:3). These results are in agreement with Enser et al. (1998) who, when comparing cattle finished with either only pasture or with concentrate, found that C18:1 and C18:3 were significantly higher in grass-fed beef, while C18:2 was lower.

The fatty-acid composition of beef deriving from the two genetic types studied was similar. Regarding the comparison of the three muscles, statistical analysis has shown several significant differences; in fact beef from the *longissimus thoracis* and *semitendinosus* muscles contained a higher percentage of palmitic (C16:0) and oleic acids (C18:1), while that from *triceps brachii* is characterized by higher percentages of pentadecenoic (C15:1), eptadecanoic (C17:0), linoleic (C18:2) and docosanoic acids (C22:0).

DISCUSSION

This study showed that Limousine bullocks or Limousine x Red pied crosses,

Tab. III. Fatty acid composition (%) of triceps brachii (Tb), longissimus thoracis (Lt) and semitendinosus (St) muscles of Limousine (L) and Limousine x Red Pied (L x RP) beef.

	Genotype (G)			Muscle (M)			
	L	L x RP	S.E.	Tb	Lt	St	S.E.
n	51	51		34	34	34	
C12:0	0.12	0.12	0.01	0.13	0.11	0.12	0.01
C14:0	2.44	2.40	0.04	2.39	2.47	2.40	0.05
C14:1	0.66	0.62	0.02	0.62	0.65	0.65	0.02
C15:0	0.53	0.48	0.02	0.50	0.52	0.50	0.02
C15:1	0.35	0.33	0.01	0.35 a	0.30 b	0.36 a	0.02
C16:0	25.50	25.16	0.15	24.88 b	25.51 a	25.59 a	0.18
C16:1	3.34	3.34	0.09	3.49	3.25	3.29	0.11
C17:0	1.04	1.07	0.04	1.20 a	0.96 b	1.01 b	0.05
C18:0	15.80	15.97	0.35	15.90	15.97	15.79	0.42
C18:1	42.06	42.47	0.45	41.12 b	42.81 a	42.87 a	0.55
C18:2	5.02	5.16	0.20	6.11 a	4.35 b	4.83 b	0.24
C18:3	1.28	1.32	0.09	1.38	1.26	1.26	0.11
C20:0	0.20	0.20	0.01	0.21	0.19	0.20	0.01
C22:0	0.73	0.76	0.05	0.98 a	0.53 c	0.72 b	0.06
Total saturated	46.35	46.16	0.48	46.18	46.27	46.32	0.58
Total unsaturated	52.72	53.24	0.40	53.07	52.62	53.25	0.49

a, b, c: $P \leq 0.05$

both organically-raised, provided carcasses with similar qualitative characteristics, while some differences in meat quality were found after comparison of genotypes and muscles. Ordinary muscular development and slight fat cover of the carcasses, in spite

of the old age of the bullocks at slaughter, and several qualitative characteristics of the meat, such as the low intramuscular fat content, showed that the feeding program of these animals was probably inadequate. In agreement with Younie (1992), it was possible to conclude that an appropriate finishing period, respecting the regulations on organic livestock farming, could allow earlier maturity for slaughter, as well as better carcass performance. Furthermore, it would lead to increase intramuscular fat content, with positive effects on some organoleptic characteristics of the beef.

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